Complications and Outcomes Associated with 13 Cases of Triceps Tendon Disruption in Dogs and Cats (2003-2014)

Authors

N F Earley, BVSc[1, 2], G Ellse BA VetMB[1], A M Wallace BVSc (Hons) MANZCVS DipECVS[3], K Parsons BVSc (Hons) PhD CertSAS DipECVS[4], K Voss Dr.med.vet DipECVS[5], L C Pugliese DVM MS DipACVS-SA[6], A P Moores BVSc DSAS (Orth) DipECVS[7], R Whitelock BVetMed DVR DSAS (Ortho) DipECVS[1, 8], C Stork Dr.med.vet DES ChirPA DipECVS[9], S Langley-Hobbs MA BVetMed DSAS (Ortho) DipECVS FHEA[1, 4], H Radke MA DrMedVet DipECVS[1]

Institutions

[1] Queen's Veterinary School Hospital, University of Cambridge, UK

[2] Royal (Dick) School of Veterinary Studies, University of Edinburgh, UK

[3]Bundoora Veterinary Hospital & Clinic, Melbourne, AU

[4]Langford Veterinary Services, University of Bristol, UK

[5]University Veterinary Teaching Hospital, Sydney, AU

[6]Veterinary Medical Centre, Ohio State University, USA

[7]Anderson Moores Veterinary Specialists, Hampshire, UK

[8]Davies Veterinary Specialists, Hertfordshire, UK

[9]Orthovet, Kent, UK

Correspondence author

Dr H Radke, Queen's Veterinary School Hospital, University of Cambridge, Madingley Road, Cambridge, CB3 0ES

hr264@cam.ac.uk

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There are no conflicts of interest

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Abstract

This study reports data from a large number of cases of triceps tendon disruption. Records from ten veterinary referral hospitals between 2003 and 2014 were searched for canine and feline cases diagnosed with triceps tendon disruption, based on orthopaedic examination confirmed during surgery. Long-term follow-up and owner satisfaction were assessed using a questionnaire. There were 13 cases of triceps tendon disruption diagnosed across seven hospitals (9 dogs, 4 cats). Trauma, history or presence of a wound, surgery in the region of tendon attachment or corticosteroid treatment preceded triceps tendon disruption. Radiographic signs or histopathology suggestive of a chronic tendinopathy was common. All cases underwent surgical repair involving a tendon suture pattern, 12 of which were secured through bone tunnels. Immobilisation was used in all cases in the form of transarticular external skeletal fixation (TAESF) (8/9 dogs) or spica splint (4 cats, 2 dogs; in one dog a TAESF was applied after complications associated with the spica splint). Complications occurred in 11 cases (17 total complications), frequently associated with the immobilisation method. One case had traumatic tendon re-rupture two years following surgery. A wound at presentation was associated with the development of multiple complications. Nine cases had long-term follow-up; five achieved normal function, four achieved acceptable function. Despite the complications, overall return to subjective normal or acceptable function, as assessed by the owners, was achieved in the majority of cases.

Introduction

Disruption of the triceps tendon is a rare condition in dogs and cats. Disruption can occur at the musculotendinous junction, within the tendon or as a tendon avulsion at the osseotendinous junction (Anzel and others 1959, Tarsney 1972). Tendon avulsion is when the tendon pulls away from the bone, sometimes accompanied by a small bone fragment. It is important to differentiate this from an olecranon avulsion fracture with an intact triceps tendon.

To date, eleven cases (2 cats, 9 dogs) of triceps tendon rupture and/or avulsion have been reported in the veterinary literature (Davies and Clayton Jones 1982, Gilmore 1984, Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and Jeong 2013, García-Fernández and others 2014, Ambrosius and others 2015). A further case report was in fact a cat with an olecranon avulsion fracture (Gilmore 1984). Previous historical findings have been acute trauma, corticosteroid treatment or chronic lameness. Typical clinical signs are non-weight bearing lameness, soft tissue swelling, pain on palpation and a transverse groove in the tendon. Mineralisation in the region of the triceps tendon attachment has been seen on radiographs and ultrasound in eight cases (Davies and Clayton Jones 1982, Gilmore 1984, Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and Jeong 2013, García-Fernández and others 2014). MRI findings have been reported in two cases (Yoon and Jeong 2013, Ambrosius and others 2015). Surgical repair is performed mostly with modified tendon suture patterns passed through bone tunnels. One case of chronic tendon rupture used a mesh graft to augment the surgical repair (Ambrosius and others 2015). All cases received external coaptation in various forms ranging from a cast to an orthotic brace. The longest follow-up period was one year (Anson and Betts 1989). All cases were reported to have normal function at the follow-up period, however, one of these

74 cases remained mildly lame (Clarke and others 2007). There have been no reports of
75 complications that have occurred post-operatively.

76 Triceps tendon rupture is also rare in humans (Balazs and others 2016, Jaiswal and others
77 2016). Acute partial injuries are often managed conservatively but complete rupture is treated
78 surgically, using transosseus tunnels (Balazs and other 2016), followed by immobilisation in
79 flexion (Tom and others 2014). A complication rate of 25% has been reported, with traumatic
80 re-rupture the most common type and wound complications being uncommon (Balazs and
81 others 2016).

82 Tendons heal slowly because they have a low metabolic rate and are relatively acellular
83 (Peacock 1959). They need to heal with considerable tensile strength without excessive scar
84 formation to allow gliding function for limb movement (Aron 1981). In chronic tendon
85 ruptures the tendinous ends contract and atrophy leaving a wide gap occupied by fibro-
86 adipose scar tissue, which needs to be excised before repairing the tendon (Us and others
87 1997). This can make the tendon repair more challenging.

88 No large case series of triceps tendon disruption in the veterinary literature has been reported.
89 The aim of this paper is to report data from a larger number of cases, with an emphasis on
90 complications of treatment and long-term follow-up. The terms 'rupture' and 'avulsion' of the
91 triceps tendon are often used interchangeably in the literature; in this study the term
92 'disruption' will be used to encompass cases of tendon rupture and tendon avulsion.

93

94 Materials and methods

Medical records from ten veterinary referral hospitals were searched for patients fulfilling the diagnostic criteria for the time period 2003 to 2014. Diagnostic criteria were canine and feline cases diagnosed with triceps tendon rupture and/or tendon avulsion, based on orthopaedic examination and confirmed during surgery. Data regarding signalment, aetiology, diagnostic findings, treatment and complications were assessed. Complications were grouped into one of three categories; 'minor' requiring no further treatment, 'major medical' requiring medical treatment or 'major surgical' requiring further surgery to treat (Cook and others 2010).

Short-term outcome was assessed by veterinary orthopaedic examination. Long-term (defined as more than 12 months (Cook and others 2010)) follow-up and owner satisfaction were assessed using a questionnaire survey completed by the owner (Appendix 1).

Subjective function was assigned to one of three categories; normal function (restoration to activity pre-injury without medication), acceptable function (restoration to limited activity compared to pre-injury with and/or without medication) and unacceptable function (all other outcomes), adapted from Cook and others 2010.

A Fisher's Exact Test was performed using statistical software (IBM SPSS Statistics Version 22) to assess whether a skin wound at clinical presentation was associated with multiple rather than single complications for dogs that had problems following tendon repair.

Results

Signalment (Appendix 2)

Patients fulfilling the diagnostic criteria were found in seven out of 10 referral institutions. Overall 13 cases of triceps tendon disruption were reported; nine dogs and four cats. The dogs had a median age of 8 years (range: 7 to 14.1 years). The median age of the cats was 4.5 years (range: 2.5 to 10 years).

History and clinical examination (Appendix 2)

Historical details associated with the triceps tendon disruption were recorded for all cases. There was a history of trauma (5/13), bite wound and/or abscess formation in the area of the triceps tendon (4/13), surgical placement of an intramedullary (IM) pin in the ulna in the region of the triceps tendon for repair of a radius and ulna fracture (2/13), and a history of having received high dosages of systemic corticosteroids over a period of time followed by an infected wound in the region of the triceps tendon (1/13). One case had no previous history of a problem associated with triceps tendon disruption.

Eleven of 13 cases presented with lameness; eight with acute onset lameness and three with chronic lameness (defined as slowly progressive lameness). Of the two cases with no recorded lameness, one case presented comatose, which meant it was not possible to assess its gait. The other case had no orthopaedic abnormalities on examination; triceps tendon rupture was only diagnosed during surgical repair of an abscess. Ten of 11 cases were non weight-bearing lame on the affected limb. Eight of 13 cases were unable to extend their elbow on clinical examination.

Pain in the region of the elbow (12/13) and soft tissue swelling (11/13) were the most common findings on palpation. Five cases were found to have a transverse groove on palpation, representing a gap between the two ends of the disrupted tendon.

Diagnostic imaging (Appendix 3)

Craniocaudal and mediolateral radiographs of the elbow were taken in 12 cases. One case did not undergo any diagnostic imaging. In nine cases the radiographs revealed either soft tissue swelling (6/12) and/or mineralised opacities proximal to the olecranon (6/12). In three of 12 cases no abnormalities were detected on the radiographs. The olecranon appeared irregular in two of 12 cases (Figure 1). Enthesiophytes were visualised on the caudal aspect of the olecranon in one of 12 cases.

In three dogs, in addition to radiography, the triceps area was examined using ultrasound prior to surgery. Complete tendon avulsion was confirmed in one case and partial rupture in another case. One case had abnormal fibre alignment, tendon swelling and mineralisation on ultrasonographic examination.

Treatment and surgical findings (Appendix 3)

All 13 cases had primary surgical repair of the triceps tendon.

Ten cases (6 dogs, 4 cats) were found to have triceps tendon avulsion. Three dogs had ruptured the distal triceps tendon. Disruption was partial in three cases and complete in five cases. In five cases it was not stated whether the disruption was partial or complete. Debrided scar tissue was submitted for histopathological analysis in one case and revealed chronic tendonitis.

All surgical repairs involved a tendon suture pattern, 12 were secured through bone tunnels in the olecranon (tendon-bone sutures). The remaining case had a direct tendon repair (tendon-tendon sutures). Three tendon suture patterns (or modified versions of these, in which the tendon is anchored to the bone through one or more bone tunnels) were used with the 3-loop pulley or modified 3-loop pulley being the most commonly used (7/13). In 12 cases concurrent paratendinous repair was reported.

All 13 cases had elbow immobilisation post-operatively. Transarticular external skeletal fixation (TAESF) was the most frequently applied measure of immobilisation, and was applied to dogs (8/9 dogs) (Figure 2). The length of time the TAESF was left in situ ranged from four to eight weeks. Three type 1a TAESF and five modified type 2 linear TAESF constructs were used. Two cases had a removable connecting bar enabling intermittent passive physiotherapy to be performed by the owner with replacement of the bar afterwards.

Six spica splints were placed (4 cats, 2 dogs). In one dog the spica splint was replaced after 12 days by a TAESF due to skin necrosis caused by the splint, in the five other cases the spica splint was maintained for three to four weeks.

Complications (Table 1)

Complications occurred in 11 of 13 cases (3 cats, 8 dogs). Four of 11 cases had more than one complication. A wound at clinical presentation was associated with multiple complications ($p=0.02$). Overall, 17 complications occurred, 15 were classified as major, requiring medical (5/17) or surgical treatment (10/17). Two complications were classified as minor, requiring no additional medical or surgical treatment to resolve. One of the most common complications was pin tract discharge (5/8 TAESFs), all of these were classified as major, with four requiring surgical treatment involving pin removal, replacement or complete

TAESF removal. The remaining case was treated medically. There were four cases of discharging wounds (4/17), one at the surgical site and three away from the surgical site. All of these were major complications. One of these cases was treated medically with open wound management, the remaining three required surgical intervention, such as debridement and primary wound closure. Three of these cases had presented with an infected wound on the elbow. Two cases developed skin necrosis secondary to the spica splint (2/6 spica splints, all dogs). Both were classified as major complications, one was managed medically, and the other case required surgery for primary wound closure. Complications in eight cases were associated with the method of immobilisation (2 cats, 6 dogs) (9/17 total complications).

Table 1: Causes and complications

Complications [#]	***Suspected or underlying causes for triceps tendon disruption***			
	Trauma	*History or presence of wound*	*Previous surgery*	*Unknown*
None	C13			C2
Minor		C3 Spica splint removed by animal 24 hours post surgery, which was replaced	C4 Spica splint - causing 10/10 lameness, resolved after splint removal 3 weeks later	
Major medical	C1 Lameness 8 weeks post surgery treated with NSAIDs C9 Spica splint - Pressure sores and skin necrosis of pes 3 weeks post surgery treated with open wound	C8 10/10 lame and pyrexia 6 weeks post surgery treated with hospitalization and intravenous antibiosis C10: 1) Discharging wound on olecranon 10 weeks post surgery	C7 TAESF - Pin tract discharge 2 weeks post surgery treated with cleaning	

	management	(away from surgical site) treated with open wound management		
Major surgical	C5 TAESF - Pin tract discharge 4 weeks post surgery treated by TAESF removal C11 1) Discharging wound on olecranon away from surgical site 4 weeks post surgery treated with dressings and delayed primary closure 2) Irritation from tendon suture 4 weeks post surgery treated by tendon suture removal following ultrasound confirmation of advanced healing 3) TAESF - Pin tract discharge 4 weeks post surgery treated with pin removal	C10 2) Spica Splint - Pressure sores and skin necrosis over olecranon 5 days post surgery treated with debridement and primary skin closure, followed by spica splint replacement at 12 days with TAESF 3) TAESF - Pin tract discharge 6 weeks post TAESF placement treated by pin removal C12 1) Discharging wounds in axilla (MRSA) 2 weeks post surgery treated with wound debridement and drain placement 2) Tendon suture failure treated with surgical revision C6 1) Discharging sinus and hygroma at surgical site 11 days post surgery treated with antibiotic beads in wound 2) TAESF - Pin tract discharge 11 days post surgery treated with pin replacement		

C+*number* = case number, see appendix for further details

Underlined = complications associated with the method of immobilization (TAESF = transarticular external skeletal fixator)

[#] Adapted from (Cook and others 2010)

Follow-up

Information about short-term outcome was available for ten cases (4 cats, 6 dogs), assessed between six and 32 weeks in the cats, and between six and 14 weeks in the dogs. Findings included muscle atrophy (7/10), reduced range of motion (7/10), pain on elbow palpation (1/10), mild or moderate lameness (6/10) and tendon thickening (6/10).

Follow-up of subjective function was available for 12 cases (4 cats, 8 dogs). Eleven cases (4 cats, 7 dogs) returned to acceptable or normal function during the follow-up period. One dog had unacceptable function peri-operatively due to the development of a major medical complication. The dog developed non-weight-bearing lameness and pyrexia six weeks after surgery and was hospitalised for treatment. No other complications had been noted with this case and it was lost to further follow-up.

Long-term follow-up of subjective function (defined as >12 months (Cook and others 2010)) was available for nine cases, between 1.2 years and 8 years post-operatively. One dog became non-weight bearing lame following a slip two years after surgery, which was thought to be due to an incomplete tear of the tendon repair because there was a small gap in the region of the tendon repair on palpation and the dog could extend its elbow. This dog improved with conservative management but was still lame at last follow-up. Five of nine cases achieved normal function and four achieved acceptable function.

One cat, achieving acceptable function, suffered an ulna and radial fracture on the same limb one month prior to triceps tendon rupture, and subsequently also fractured the right calcaneus, and later partially ruptured the gastrocnemius tendon.

Discussion

A possible cause or contributing factor for the triceps tendon disruption was identified in most cases in this study (12/13), this was either as an acute incident or up to five years previously. Trauma (5 cases) and prior corticosteroid use (1 case) has been formerly reported as possible inciting causes of triceps tendon disruption (Davies and Clayton Jones 1982, Gilmore 1984, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and Jeong 2013, García-Fernández and others 2014, Ambrosius and others 2015). Corticosteroid treatment whether given systemically or via tendon infiltration has been widely associated with cases of tendon rupture including triceps, biceps and common calcaneal tendons (Unverferth and Olix 1973, Halpern and others 1977, Newnham and others 1991, Stannard and Bucknell 1993). Presence and/or prior history of a wound (5 cases) or previous surgery (2 cases) in the region of the triceps tendon as possible inciting causes have not been reported previously. These factors may negatively affect the mechanical properties of the tendon by disrupting collagen fibre alignment, thereby interfering with collagen fibre elongation and interfibrillar shear (Sasaki and Odajima 1996), and therefore the tendon might be more susceptible to rupture even under a normal physiological load (James and others 2008). In the two cases that underwent previous surgery, tendon injury was suspected to have resulted from the proximal tip of an IM pin in the ulna. Careful surgical technique by placing and bending the IM pin away from the tendon attachment should be employed to minimise the risk of this complication

Evidence of a pre-existing tendinopathy, diagnosed as mineralised opacities in the area of triceps tendon insertion on radiographs or ultrasound examination, or with histopathology, was observed in seven of 13 cases in this study. Imaging features of a chronic tendinopathy has been identified in previous reports (Davies and Clayton Jones 1982, Gilmore 1984, Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and

241 Jeong 2013, García-Fernández and others 2014). Two of our six cases had radiographic
242 evidence of mineralisation but no reported previous problem or chronic lameness.
243 Mineralised opacities are likely to occur through dystrophic calcification stimulated by
244 previous or repetitive trauma with disturbance of the tendon blood supply (Muir and others
245 1992). Therefore, it is possible that these two reportedly acute cases either had a chronic
246 underlying disease process or the clinical signs were subtle and had been overlooked.
247 Histopathology is needed to confirm the pathology; chronic tendonitis was diagnosed
248 histologically in one dog in this study with chronic lameness, this patient had no significant
249 findings on radiographs or ultrasound. Hence, absence of mineralisation on diagnostic
250 imaging does not rule out a chronic tendinopathy.

251 In the present study, triceps tendon avulsion occurred more commonly (10/13 cases)
252 compared with distal triceps tendon rupture (3/13 cases). Three cases in this study were found
253 to be a partial triceps tendon disruption. These were subsequently repaired surgically. In
254 humans primary surgical repair is indicated with complete triceps tendon rupture to restore
255 functional extension strength to the elbow (Singh and Pooley 2002), but non-surgical
256 treatment for partial triceps tendon rupture has been described (O'Driscoll 1992). It is not
257 known, if conservative treatment may be effective in canine and feline patients with a partial
258 rupture.

259 The data in this study is not suitable to compare the different surgical techniques used to
260 repair triceps tendon disruption, but demonstrated an overall trend to use a tendon suture
261 pattern, particularly the 3-loop pulley and its modified version (7/13), secured through bone
262 tunnels (12/13) with polyproplyene or polydioxanone suture material. The available data is
263 also not appropriate to demonstrate a clear advantage of one method of immobilisation over
264 the other, but there seems to be a tendency to use spica splints in cats and a TAESF in dogs

for three to eight weeks. Custom made orthotic braces, as used in one recent case report may offer a viable alternative (García-Fernández and others 2014), but more data would be needed to confirm this.

In previous case reports, only one complication was documented, a non-weight bearing lameness at eight weeks following splint removal in a dog (Anson and Betts 1989). In our study there were a high number of complications (11/13 cases), with several complications requiring medical and/or surgical intervention. It seems that many of the complications in this study were related to the immobilisation method. In the triceps tenotomy study in dogs by Dueland and Quenin 1980, immobilisation was not used post-operatively, but these cases were controlled surgical transections with an immediate surgical repair. Due to the relatively small number of cases in this study it is not possible to make firm conclusions but it did appear that there were fewer complications in the cats where a spica splint was placed, compared to the dogs with a TAESF placed. This highlights that early recognition and treatment of complications secondary to TAESF is very important (Egger 1991), and the associated importance of informing the owner about the possible risk and the signs of these complications. Only one case had failure of the initial tendon repair and this is likely related to the development of a multi-resistant infection post-surgery.

In our study there were 12 cases with follow-up information. Following limb immobilisation, muscle atrophy, lameness and reduced range of motion were frequent findings in this study, similar to previous reports (Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Ambrosius and others 2015). Two cases with a removable connecting bar to enable passive physiotherapy had only a mild reduction in range of motion recorded at eight and 12 weeks. Both of these cases achieved normal function by six months post-surgery. Three previously reported cases were found to have a successful outcome following

289 controlled increase in range of elbow motion after a period of rigid immobilisation (García-
290 Fernández and others 2014, Ambrosius and others 2015). Early mobilisation should be
291 encouraged as it places physiological loads on healing structures, reduces intra-articular
292 adhesions and helps orientate collagen fibres along lines of stress whilst increasing tensile
293 strength of tissues (Jaegar and others 2005). Gradual remobilisation enables increases in joint
294 range of motion whilst maintaining the stiffness of articular cartilage (Jaegar and others
295 2005). The use of a TAESF with a removable connecting bar assisting gradual remobilisation
296 of the elbow in dogs is an area that may warrant further research.

297 Nine cases had long-term follow-up of more than one year, this is longer than previously
298 reported. All cases achieved a good outcome; five normal function (2 cats, 3 dogs) and four
299 acceptable function (1 cat, 3 dogs). The main complication reported in human literature is re-
300 rupture of the tendon repair (Van Riet and others 2003, Balazs and others 2016). This was
301 documented in one dog in this study, with a partial tear following a slip two years after
302 surgery. This dog responded to conservative management but remained lame at the last
303 recheck three months post surgery.

304 The small number of cases and the retrospective design are the major limitations of this
305 study. These problems need to be considered when interpreting the results. In order to obtain
306 maximal case numbers for this rare condition, a multicentre approach was employed. Due to
307 this study design there are different time intervals for assessing short-term outcome. Three
308 cases were lost to further follow-up.

309 This report documents the complications and outcome of a large number of cases following
310 repair of triceps tendon disruption in dogs and cats. In addition to trauma, the use of systemic
311 corticosteroids, history and/or presence of a wound and surgery performed for fracture repair

in the area of tendon attachment can precede triceps tendon disruption. Diagnostic imaging suggestive of chronic tendinopathy was a common finding in this study, whether or not there was a history of consistent clinical signs. However, absence of mineralisation does not rule out a chronic disease process and histopathology is necessary for confirmation. Surgical repair with modified tendon suture patterns using the olecranon as an anchorage point was the main form of primary surgical repair. Subsequently, limb immobilisation was achieved via spica splint or TAESF for a minimum of three weeks. Complications were common, and generally required medical or surgical intervention. There was one case of tendon re-rupture. A wound at presentation was associated with the development of multiple complications. Despite this, overall return to subjective normal or acceptable limb function was achieved in most cases.

References

Ambrosius L, Arnoldy C, Waller III KR, Little JP & Bleedorn JA. (2015) Reconstruction of chronic triceps tendon avulsion using synthetic mesh graft in a dog. Veterinary and Comparative Orthopaedics and Traumatololgy 28, 220-224.

Anson LW & Betts CW. (1989) Triceps tendon avulsion in a dog: Surgical management and xeroradiographic evaluation. Journal of the American Animal Hospital Association 25, 655-658.

Anzel SH, Covey KW, Weiner AD & Lipscomb PR. (1959) Disruptions of muscles and tendons: an analysis of 1,041 cases. Surgery 45, 406-414.

Aron DN. (1981) A “new” tendon stitch. Journal of the American Animal Hospital Association 17, 587-591.

334 Balazs GC, Brelin AM, Dworak TC, Brooks DI, Mauntel TC, Tintle SM & Dickens JF.
335 (2016) Outcomes and complications of triceps tendon repair following acute rupture in
336 American military personnel. Injury 47, 2247-2251.
337 Clarke SP, Jermyn K & Carmichael S. (2007) Avulsion of the triceps tendon insertion in
338 a cat. Veterinary and Comparative Orthopaedics and Traumatology 20, 245-247.
339 Cook JL, Evans R, Conzemius MG, Lascelles BD, Mcllwraith CW, Pozzi A, Clegg P,
340 Innes J, Schulz K, Houlton J, Fortier L, Cross AR, Hayashi K, Kapatkin A, Brown DC &
341 Stewart A. (2010) Proposed definitions and criteria for reporting time frame, outcome and
342 complications for clinical orthopedic studies in veterinary medicine. Veterinary Surgery
343 39, 905-908.
344 Davies JV & Clayton Jones DG. (1982) Triceps tendon rupture in the dog following
345 corticosteroid injection. Journal of Small Animal Practice 23, 779-787.
346 Dueland R & Quenin J. (1980) Triceps tenotomy: Biomechanical assessment of healing
347 strength. Journal of the American Animal Hospital Association 16, 507-511.
348 Egger EL. (1991) Complications of external fixation. A problem-orientated approach.
349 Veterinary Clinics of North America: Small Animal Practice 21(4), 705-733.
350 García-Fernández P, Quero Martín P, Mayenco A, Gardoqui M & Calvo I. (2014)
351 Surgical management and follow-up of triceps tendon avulsion after repeated local
352 infiltration of steroids: two cases. Veterinary and Comparative Orthopaedics and
353 Traumatology 27, 405-410.
354 Gilmore DR. (1984) Triceps tendon avulsion in the dog and cat. Journal of the American
355 Animal Hospital Association 20, 239-242.
356 Halpern AA, Horowitz BG & Nagel DA. (1977) Tendon ruptures associated with
357 corticosteroid therapy. The Western Journal of Medicine 127, 378-382.

358 Jaegar GH, Wosar MA, Marcellin-Little DJ & Lascelles BD. (2005) Use of hinged
359 transarticular external fixation for adjunctive joint stabilization in dogs and cats: 14 cases
360 (1999-2003). Journal of the American Veterinary Medical Association 227(4), 586-590.
361 Jaiswal A, Kacchap ND, Tanwar YS, Kumar D & Kumar B. (2016) Rupture of the triceps
362 tendon – A case series. Chin J Traumatol 19, 235-238.
363 James R, Kesturu G, Balian G & Chhabra AB. (2008) Tendon: Biology, biomechanics,
364 repair, growth factors and evolving treatment options. The Journal of Hand Surgery
365 33(1), 102-112.
366 Liehmann L & Lorinson D. (2006) Traumatic triceps tendon avulsion in a cat. Journal of
367 Small Animal Practice 47, 94-97.
368 Muir P, Goldsmith SE, Rothwell TLW & Bellenger CR. (1992) Calcifying tendinopathy
369 of the biceps brachii in a dog. Journal of the American Veterinary Medical Association
370 201(11), 1747-1749.
371 Newnham DM, Dougleas JG, Legge JS & Friend JA. (1991) Achilles tendon rupture: an
372 underrated complication of corticosteroid treatment. Thorax 46(11), 853-854.
373 O'Driscoll SW. (1992) Intramuscular triceps rupture. Canadian Journal of Surgery 35(2),
374 203-207.
375 Peacock EE Jr. (1959) A study of the circulation in normal tendons and healing grafts.
376 Annals of Surgery 149(3), 415-428.
377 Sasaki N & Odajima S. (1996) Elongation mechanism of collagen fibrils and force-strain
378 relations of tendon at each level of structural hierarchy. Journal of Biomechanics 29(9),
379 1131-1136.
380 Singh RK & Pooley J. (2002) Complete rupture of the triceps brachii muscle. British
381 Journal of Sports Medicine 36, 476-469.

Stannard JP & Bucknell AL. (1993) Rupture of the triceps tendon associated with steroid injections. The American Journal of Sports Medicine 21(3), 482-485.

Tom JA, Kumar NS, Cerynik DL, Mashru R & Parella MS. (2014) Diagnosis and treatment of triceps tendon injuries: a review of the literature. Clin J Sport Med 24(3), 197-204.

Tarsney FF. (1972) Rupture and avulsion of the triceps. Clinical Orthopaedics and Related Research 83, 177-183.

Unverferth LJ & Olix ML. (1973) The effect of local steroid injections on tendon. The Journal of Sports Medicine 1(4), 31-37.

Us AK, Bilgin SS, Aydin T & Mergen E. (1997) Repair of neglected Achilles tendon ruptures: procedures and functional results. Arch Orthop Trauma Surg 116(6-7), 408-411.

Van Riet RP, Morrey BF, Ho E & O'Driscoll SW. (2003) Surgical treatment of distal triceps ruptures. The Journal of Bone and Joint Surgery, American volume 85(10), 1961-1967.

Yoon HY & Jeong SW. (2013) Traumatic triceps tendon avulsion in a dog: Magnetic resonance imaging and surgical management evaluation. The Journal of Veterinary Medical Science 75(10), 1375-1377.

Legends

Figure 1

Medio-lateral radiograph of the left elbow of a 10 year old female neutered (FN) domestic short hair (DSH) (case 2) with presumed acute triceps tendon disruption. This radiograph shows small mineralised opacities in the region of triceps tendon insertion, soft tissue swelling and a roughened olecranon. The finding of mineralisation is more consistent with a chronic tendinopathy, rather than an acute disruption.

Figure 2

Photo of a 7 year old FN Staffordshire bull terrier (case 7) with a type 1a hinged TAESF applied to the lateral aspect of the left humerus and radius to span the elbow. The connecting bar was removable to allow passive flexion and extension of the elbow.